The Oil Drum
DISCUSSIONS ABOUT ENERGY AND OUR FUTURE

The Disconnect Between Oil Reserves and Production

Posted by Gail the Actuary on March 6, 2008 - 11:00am
Topic: Supply/Production
Tags: canadian oil sands, fsu, oil reserves, opec, peak oil [list all tags]

This post includes some ideas of Matt Mushalik, plus some of my analysis. Matt is a retired civil engineer and regional planner from Sydney, Australia.

If a person looks at published oil reserves, it is easy to get the idea that there are huge amounts of oil left to be extracted. One would think that there is no way that peak oil should be a concern. Once we look at the situation a more closely, we discover that published oil reserves really aren't all that helpful in telling us about future production. In fact, the evidence suggests that oil shortages may not be many years away.

1. How much oil reserves are shown in published reports?

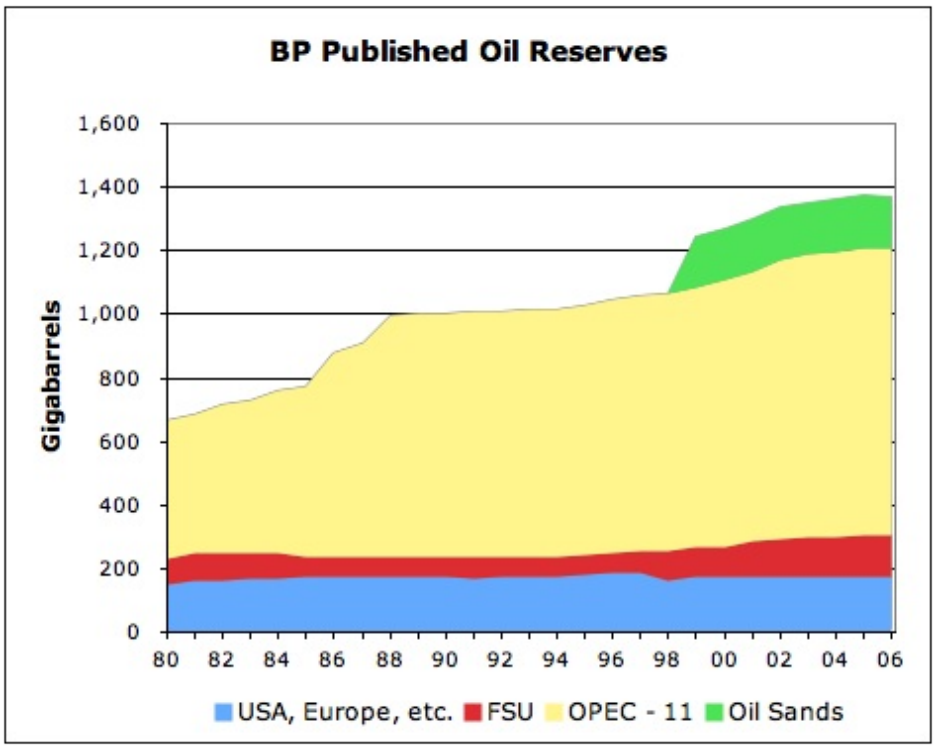

Figure 1

Most reports show reserves similar to those shown above, which were compiled by British Petroleum (BP). The major categories shown on Figure 1 are

• Canadian oil or tar sands. Generally considered a resource, rather than a reserve. (Shown separately by BP.) Oil sands resource was first listed by BP in 1999, even though commercial production began in 1967.

• OPEC 11. Excludes Angola (added to OPEC in 2007), and Ecuador (added recently).

• FSU. Former Soviet Union.

• USA, Europe, etc. Everything else other than Canadian oil sands, OPEC 11, and FSU. Includes Australia, Canada, China, Mexico, and many other counties.

In this analysis, the term "gigabarrels" (abbreviated Gb) is used to mean 1,000 million barrels, or 1 billion barrels in USA terminology.

2. How does the distribution of actual oil production compare with the distribution of published reserves?

It is very different:

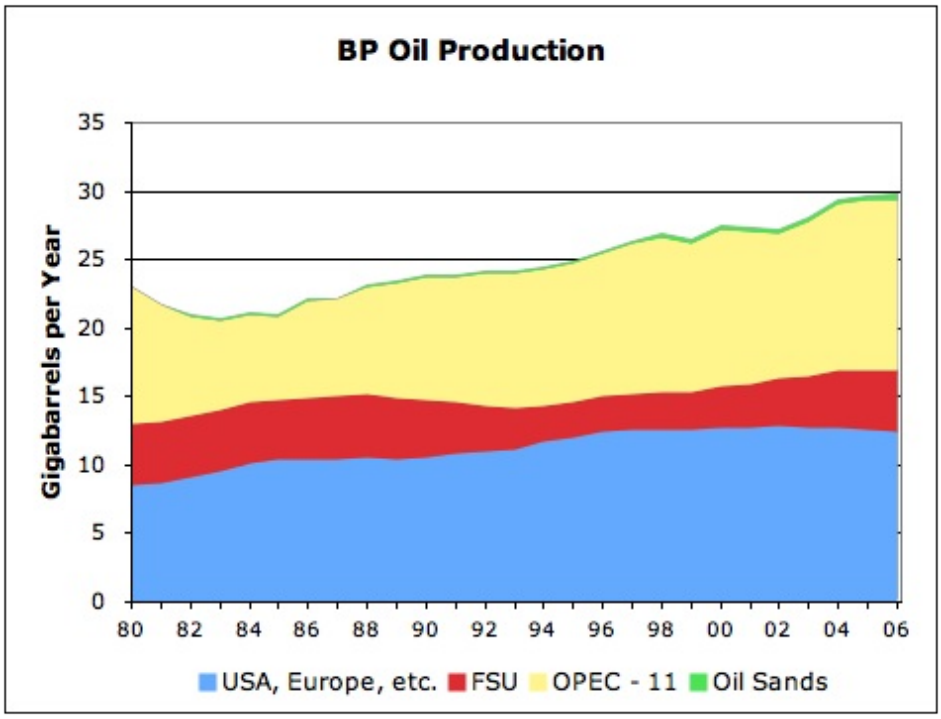

Figure 2

Production from the Canadian oil sands is just a thin ribbon, year after year, in spite of the apparently large size of the available resources. OPEC 11 has far less production than might be expected by their "proven reserves." USA, Europe, etc. has much higher production than might be expected based on the size of their reserves. If one graphs the ratio of production to reserves, one obtains the following:

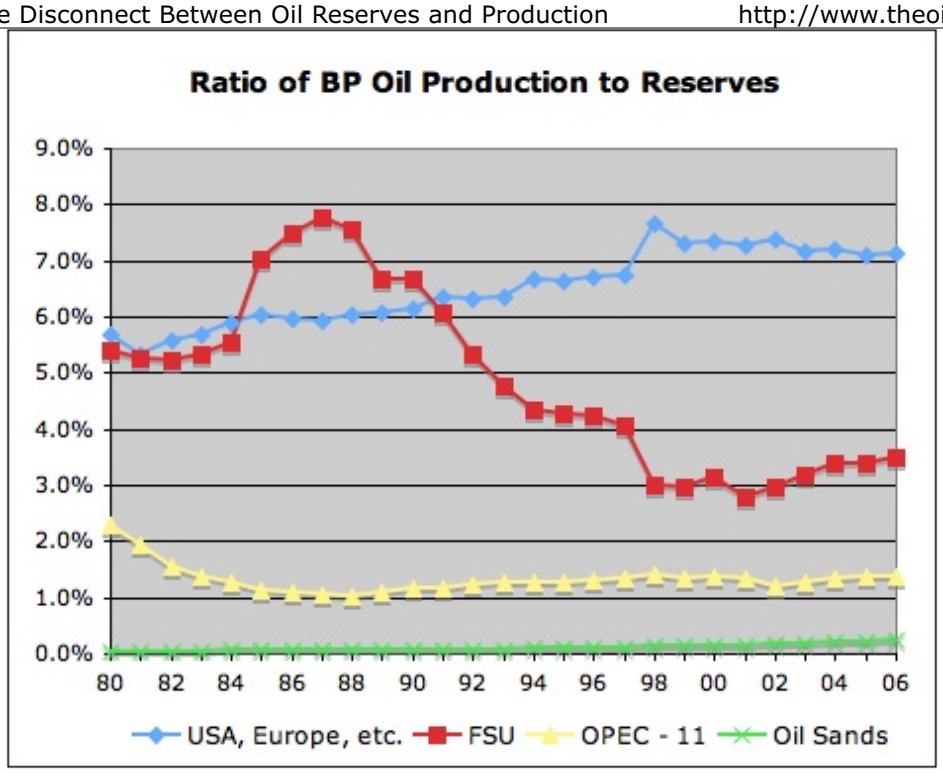

Figure 3

It is clear from this graph that the ratio of production to reserves varies considerably from group to group. It can also vary over time, as shown by the fact that the ratio for FSU is shifting downward over time.

There seems to be an anomaly in the BP data in 1998, which was the year production for FSU was shown by country for the first time. In 1998, there was a 23Gb increase in FSU reserves, and corresponding decrease in reserves for the USA, Europe, etc. group. Apparently, reserves for one or two countries got shifted between the two groups at that time. This anomaly causes the jump in the 1998 production to reserve ratios in Figure 3.

3. Aren't published reserves a leading indicator for future production?

One might expect reserves to be a leading indicator, but when one looks at historical data on an aggregate basis, it is difficult to see much evidence that this is in fact the case.

• USA, Europe, etc. Oil reserves are essentially flat from 1980 to 2006, while oil production first rose, then peaked and began to decline. One would never guess the rise and fall in oil production from the reserves.

• USA by itself Both oil production and oil reserves have been falling since prior to 1980. Oil production has tended to fall more quickly than oil reserves, as evidenced by the decline in the production to reserve ratio over time. If reserves were a leading indicator of depletion, one might expect this ratio to rise rather than fall over time.

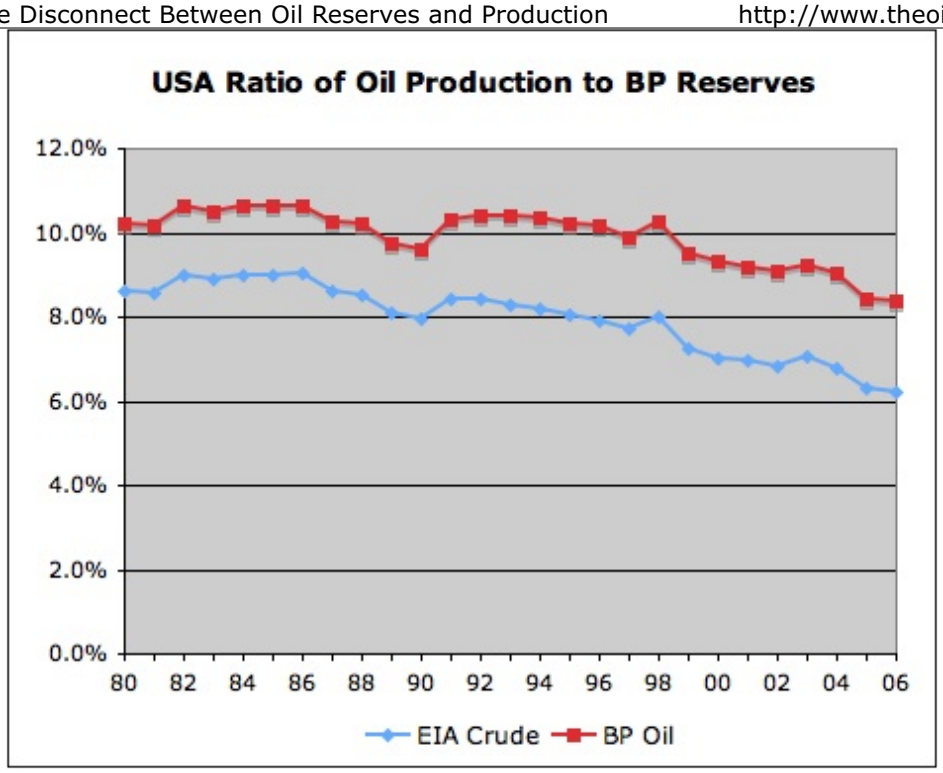

Figure 4

• OPEC 11 Several OPEC members publish very high reserve numbers, but have never offered production at the level one might expect from the quoted reserves.

• FSU Russia quotes its reserves at "P3" level, a level that is quite a bit higher than the level mandated by the US Securities and Exchange Commission (SEC). Besides P1 or proved reserves, which are all the SEC permits, it includes amounts that are expected with improvements in technology and economics, and even amounts that may be possible in the future, with future technology. The big drop in the ratio of production to reserves in recent years may indicate a more aggressive view of what may be possible in the future.

• Oil sands The hot water extraction process similar to that used todaywas patented in 1928, and the first large-scale commercial extraction began in 1967. While a huge amount of the resource is present and there has been a great deal of investment ($10.4 billion in 2005), production remains low -- currently a little over 1% of world oil supply. According to Statistics Canada, 2007 production is expected to increase by 2.2% over 2006 production.

4. Does everyone use the same rules in determining oil reserves?

No. Companies which follow the US SEC rules are required to set reserves at the P1 level -- the amount that is clearly available with current technology and current economic conditions. Availability must be demonstrated by actual production or commercial formation tests. Some countries use P2 reserves -- reserves that are at the "expected" level. Others use P3 reserves, incorporating amounts that may be possible with future technology and higher oil prices. I am not aware of aggregate data regarding the difference in these reserve levels, but some company level data suggests that at times they can be very large (for example, here and here).

Now that companies are having increasing difficulty replacing their SEC reserves due to depletion, the SEC is considering modernizing its rules. The changes are expected to increase the amount of reserves companies can record.

Reserve amounts reported by countries to statistical organizations are generally not audited. BP reports whatever countries report to it, without adjustment. When these amounts are published in newspapers and books, they are often referred to as "proven reserves," even though they use different definitions and are not audited.

Based on US data, the data BP publishes appears to be on a crude + condensate + natural gas liquids basis. Biofuels are excluded, as are processing gains.

5. Is there any evidence that the oil reserves for OPEC are overstated?

There is a great deal of evidence that this is the case.

• Matt Simmons obtained copies of more than 200 scientific papers published by scientists working on Saudi Arabian oil production. Based on his review of these papers, Simmons came to the conclusion that reservoirs in Saudi Arabia were at an advanced stage of depletion, and that the reserves were significantly overstated. His findings were published in the book Twilight in the Desert in 2005.

• Several of the OPEC countries adjusted their reserves upward in the 1980s, without any new oil discoveries, at a time when there was discussion about how production quotas should be allocated. It was believed that having higher reserves would be beneficial when quotas were assigned, so each country in turn raised its reserves. Logically, reserves should be declining in recent years, as oil is pumped out, and virtually no new fields are added, but this is not happening.

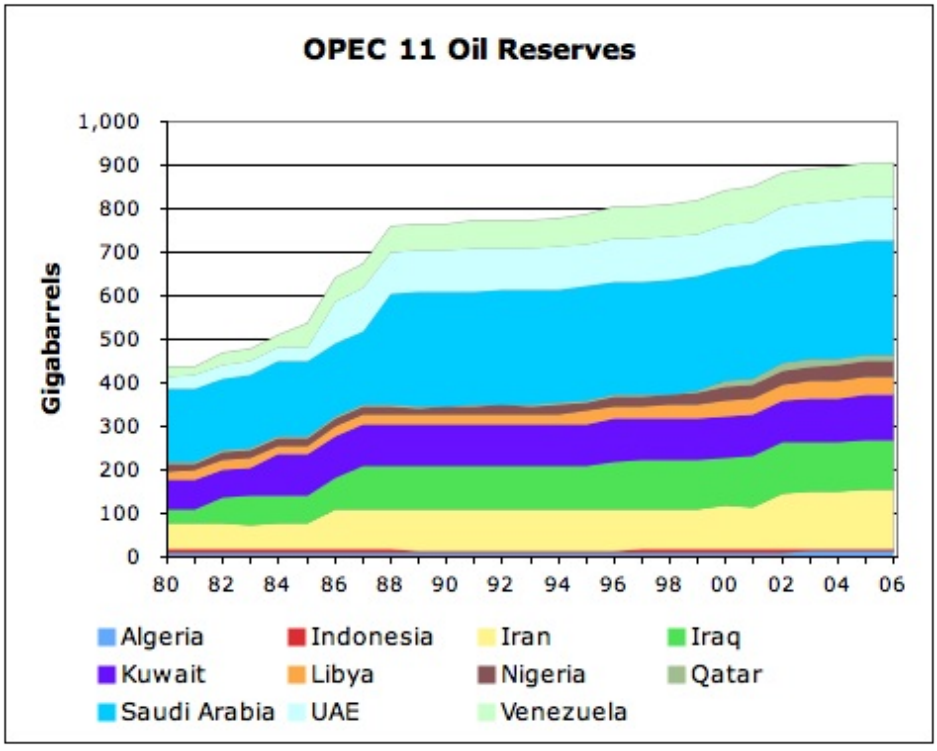

Figure 5

• Dr. Sadad I. Al Husseini, former Executive Vice President of Aramco (Saudi Arabia's national oil company), gave a presentation last October in which he stated that OPEC oil reserves are overstated by more than 300 Gb. If the amount is 300 Gb, it would correspond to about one-third of current reserves. His presentation says *more than*, so this is a floor, not a best estimate.

• A report by the reserves committee of the Kuwait oil company shows only 24.2 Gb of proven reserves (48.1 Gb if non-proven reserves are included) at the end of 2001, while published reserves as of the same date were 96.5 Gb. This was only 25% of the published level.

• The amount of oil produced by OPEC, relative to the amount of stated reserves, is very low. Some of this may be the result of very heavy oil that cannot be produced very quickly, such as that found in Venezuela (similar to the Canadian oil sands). Some other oil may be bypassed, because of war and sanctions, as in Iraq. Even allowing for this, the reserves would be much more reasonable in relationship to production if they were half of their stated amount, or even less.

• While OPEC claims extra capacity, its actions are not consistent with having much extra capacity. It seems likely that much of the claimed extra capacity relates to oil that is difficult to refine. No buyers are available, because no refineries can handle the particular impurities of the oil.

6. Is there a way of representing the disproportionate nature of the reserves and production graphically?

Matt Mushalik has prepared a graph showing the disproportionate nature of reserves and production. According to his calculations, 45% of oil production comes from only 190 GB of reserves. If these should deplete, there will be very serious implications for world production.

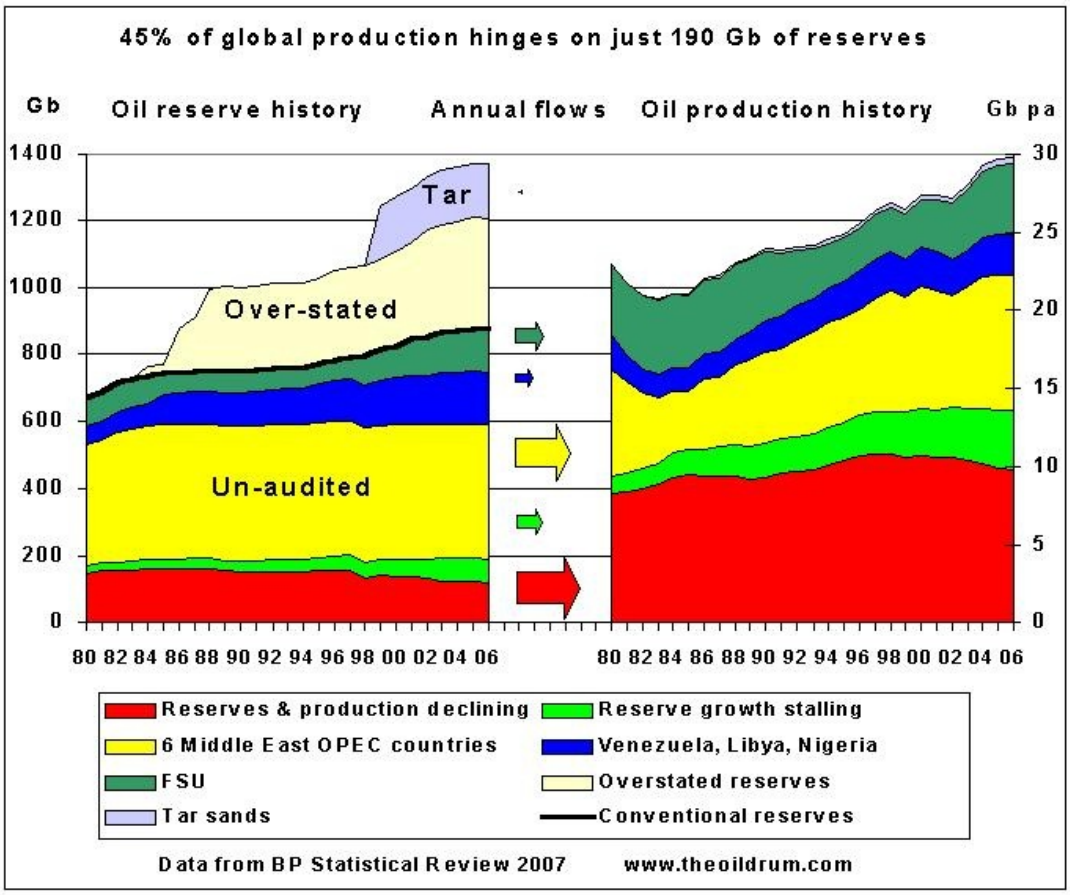

Figure 6

Matt's groupings are a little different from mine. He shows several of the OPEC countries separately and groups the remaining countries by whether their reserves are increasing over time or decreasing over time. Matt has written about the disconnect between reserves and

production in World's Fragile Oil Flows From Declining Reserve Base.

7. Doesn't the US Geological Service (USGS) say that huge amounts of oil are yet to be discovered, and that current reserves will prove to be too low, rather than too high?

Yes. The latest USGS study does show 649 Gb of undiscovered oil and 612 Gb of "reserve growth". The methodology of this analysis is seriously in doubt, according to a report by Jean Laherrere. In this report, USGS does not adequately reflect the fact that the rate of discoveries has been falling.

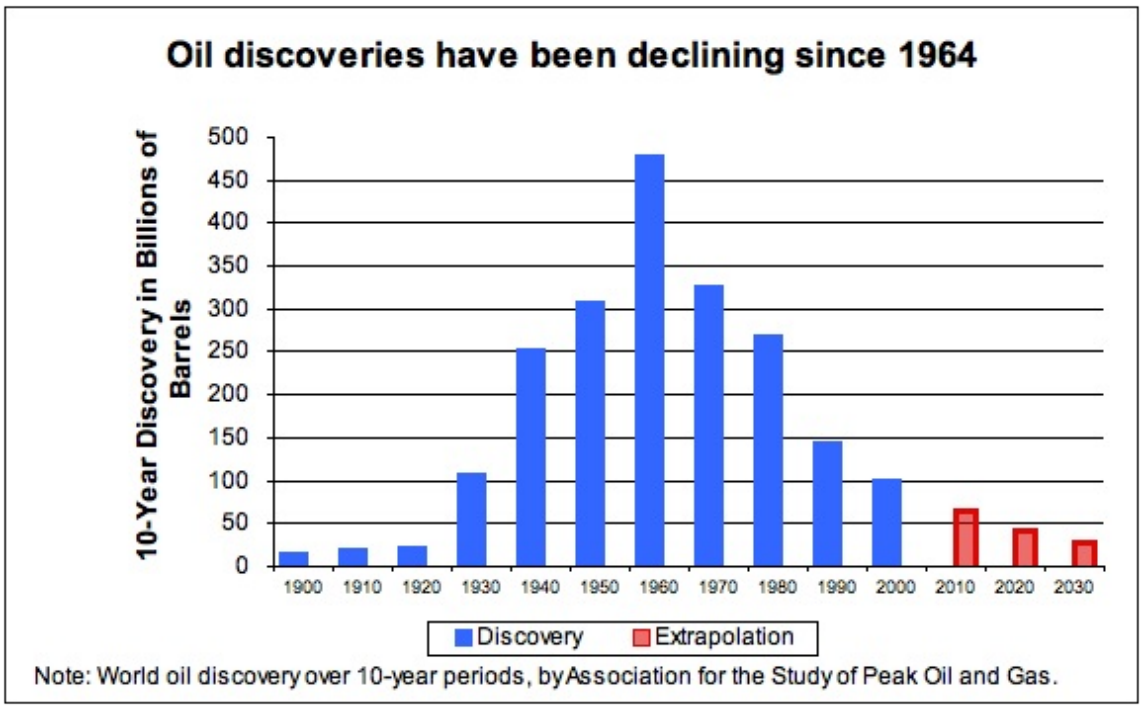

Figure 7

The USGS also determines expected reserve growth in an inappropriate manner. They determine reserve growth based on historical experience for companies using SEC reserves. They apply this approach world-wide, without considering the type of reserves reported by other countries. In countries where reserves are inflated, this adjustment has the effect of inflating them further. If the ratio of US production to reserves has been declining over time, it is likely this approach will even overstate future US reserve growth.

8. Which of the groups "USA, Europe, etc.", FSU, and OPEC are past peak production?

• USA, Europe, etc. The grouping USA, Europe, etc. is fairly clearly past peak production. The USA, the North Sea, and Mexico are all past peak, as are Canadian conventional production and Australia. The only other major producer that is not past peak is China, and its production is increasing very little. Angola and Ecuador, which have recently joined OPEC, are shown in this group, but even with their inclusion, production is dropping.

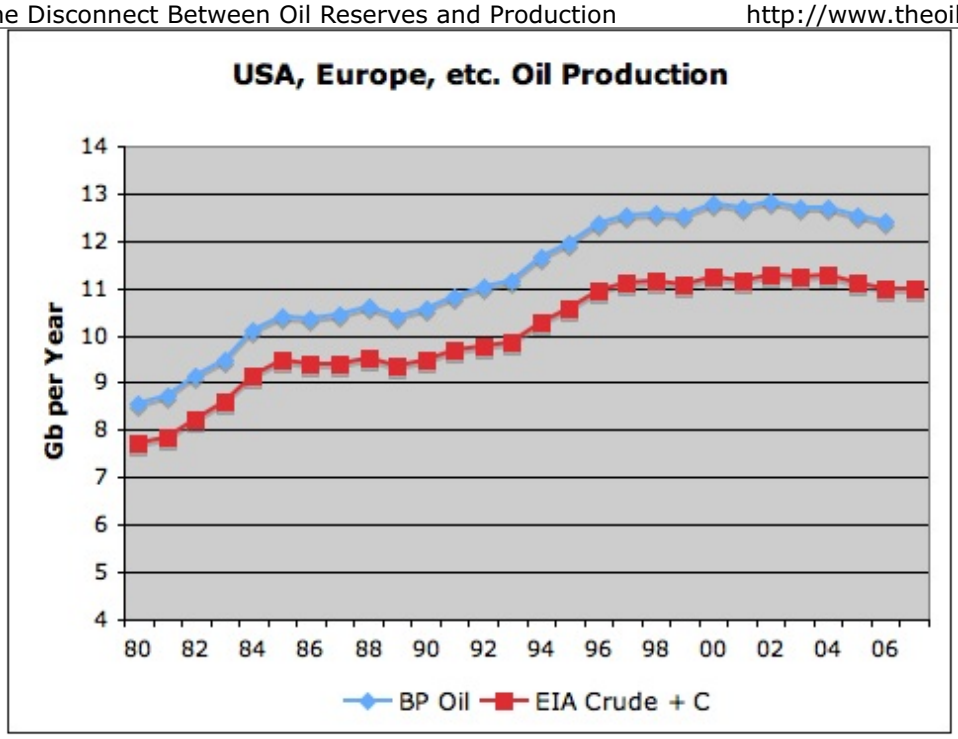

Figure 8

It is logical that this group should peak first, because it includes most of the heavy users of oil, and they generally extracted their own oil first.

EIA data through November 2007 is shown because it gives nearly the full 2007 year, while BP does not yet include 2007. The reason BP data is consistently higher than EIA data is because it includes natural gas liquids, while EIA data includes only crude and condensate. Since EIA does not show a subtotal for FSU, it was necessary to estimate this amount by combining data for the available countries, and adding an estimate for countries not shown separately, based on BP data for this segment.

• Former Soviet Union Oil production for the FSU does not yet appear to have peaked.

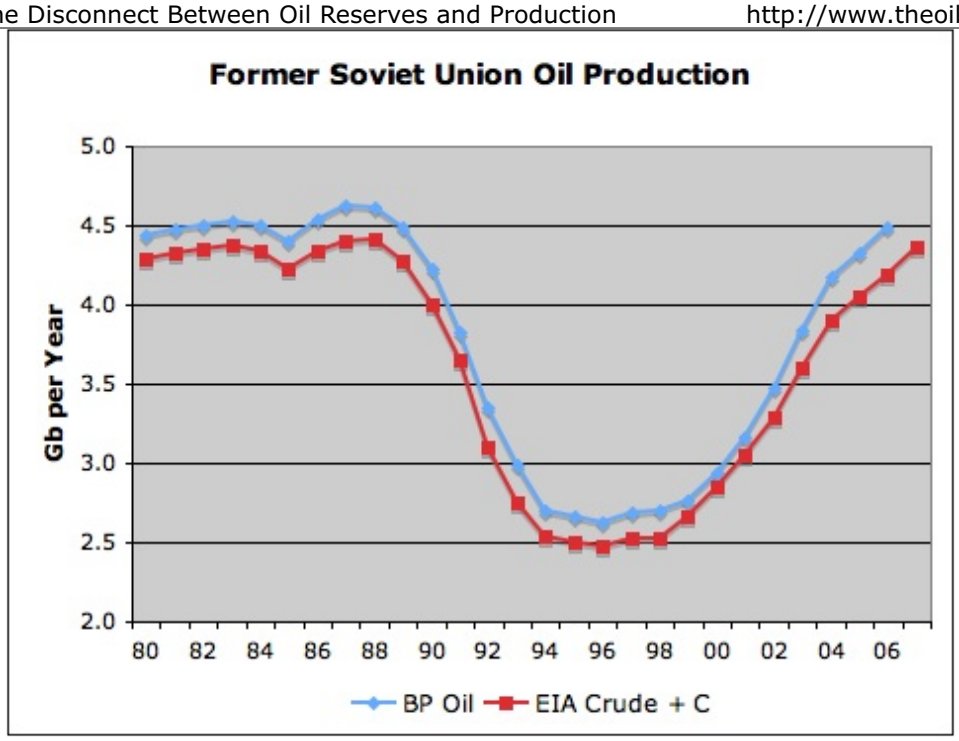

Figure 9

Production dropped in the early 1990's, and is now getting back to the level it was previously. It is not clear that it will ever exceed its previous peak. There are frequent reports that Russian production is expected to level off or decline in the future; the smaller countries are limited in their production capability by infrastructure limitations. Thus, increases in the future are likely to be small, at least in relationship to declines in production of the USA, Europe, etc. group. Thus, this group is not likely by itself to save us from peak oil.

• OPEC 11 It is possible that OPEC-11 is past peak, but this is not yet certain. BP indicates a small up-tick in OPEC 11 production in 2006, but EIA data shows a decrease in both 2006 and 2007 production.

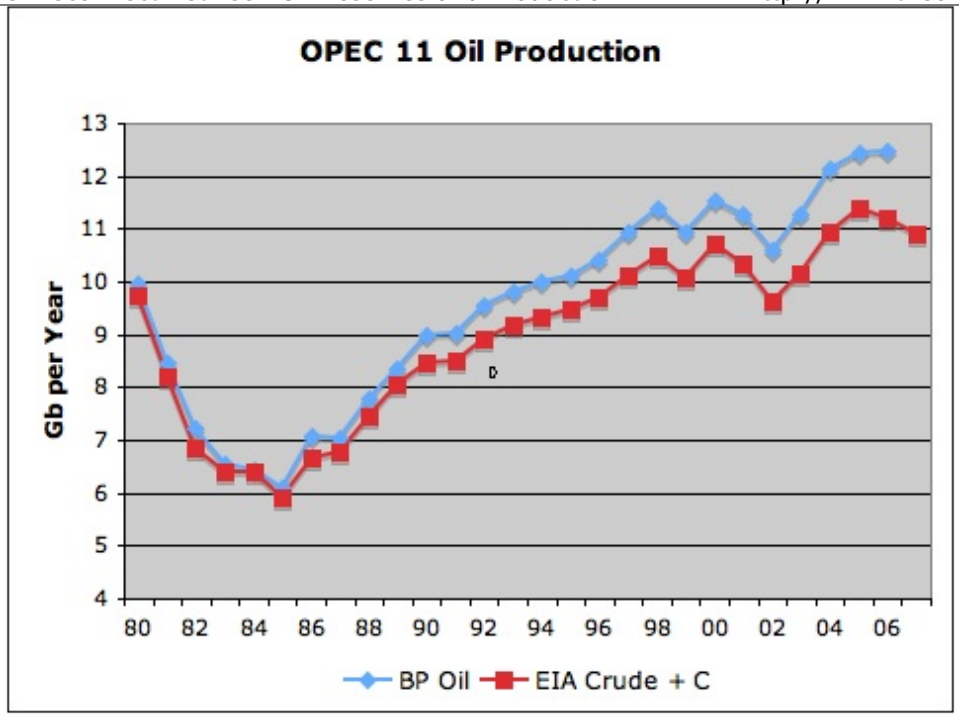

Figure 10

If one looks more closely at OPEC 11 production using Matt Mushalik's graph of incremental EIA production (showing just recent changes in production), one can see that that while Saudi Arabian oil production is not as low as it was in early 2007, it is nowhere near where it was in mid-2005.

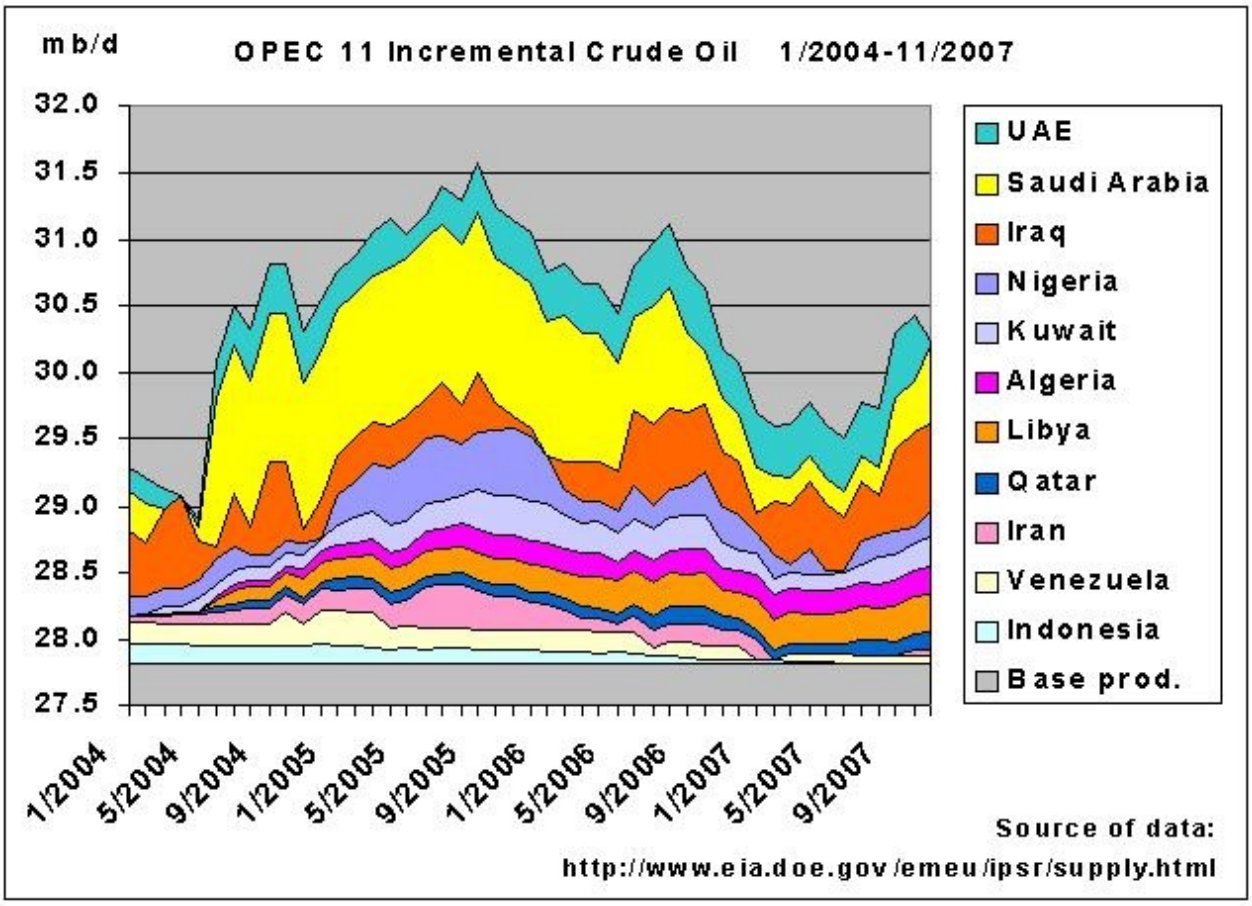

Figure 11

The lower Saudi production raises questions about OPEC 11's ability to raise its production. This is one to watch--once OPEC 11 is past peak, it is very likely that the world is past peak. We know so little about "real" OPEC reserves that reserve levels cannot be used to eliminate this possibility.

9. Can the Canadian oil sands save us from peak oil?

Can the perpetual sliver ever be anything else? It is difficult to see how Canadian oil sands production will expand very much, very quickly. According to the Master's thesis of Bengt Söderbergh, natural gas availability is likely to limit oil sands production in the long term. With or without the natural gas limitation, there are many other concerns, including environmental impact, greenhouse gas emissions, and very high continuing investment. Optimistic estimates of production are about four times current production by 2030. This would be about 5% of current world production--still not very much.

It is possible that one of the new production techniques, such as Toe to Heel Air Injection, will prove to be effective. If this happens, oil sands production may increase by even more than that forecast in the current optimistic target. If such an increase does occur, much of the benefit is likely to be after 2020. Such an increase could theoretically help mitigate the downslope after the peak in world oil production. The increase, should it occur, is likely be too late and too small to prevent the peak.

10. Does this type of analysis say anything about depletion rates?

Possibly. Cambridge Energy Research Associates (CERA) published an analysis indicating that if one looks at a mixture of fields that are increasing and decreasing, the overall decline rate is 4.5%.

If CERA looks at the decline rate for a mixture of increasing and decreasing fields, it sounds like CERA is looking at the *depletion rate* with respect to reserves at a point in time. This is in contrast to a *decline rate*, which one generally thinks about as occurring after individual field's peak or plateau.

While CERA made its calculation with individual field data, another approach would be to start with aggregate data relating to the (production / reserves) ratio, such as BP data. A person would then make adjustments to the aggregate data. One adjustment would be to remove reserves relating to fields that are not yet in production from the total reserve amount. Another adjustment might be to put reserves on a P2 (that is expected) basis, if companies report them on a P1 or P3 basis. Another adjustment is a small timing adjustment - the payments during one year should relate to reserves at the end of the previous year, instead of the end of the current year. Ratios before adjustment are shown in Figure 3.

The ratio before adjustment for the USA, Europe, etc. group is 7.1% (Figure 3). It seems likely that even after adjustment, it would be higher than 4.5%.

The ratio before adjustment for the FSU group is 3.5%. Two adjustments are needed:

1 .To reduce the reserves because reserves are on a P3 basis, and thus are higher than the expected or P2 level.

2. To reduce the reserves by the amount relating to fields not yet in production.

Both of these adjustments would tend to reduce the denominator of this ratio, and thus increase the ratio. With these adjustments, it is likely that the FSU ratio would also be over 4.5%.

OPEC reserves, as published, are too unreliable for this approach to work. If a person had a better analysis of reserve figures for OPEC, it could perhaps be applied.

11. What should we do now?

Given the likely shortage of oil in the future, and the likely environmental impacts whether or not there is an oil shortage, it would be best to start taking action now to reduce usage of oil and other fossil fuels.

Figure 12

We are now running out of time to implement urban rail solutions as is being done in the Australian City of Perth. In Perth, rail lines run alongside the freeways. Rail stations have bus terminuses on top the rail stations, and kiss & ride and park & ride facilities nearby. This is ideal for getting to the station in various ways and a quick train-ride to the city.